Light emitting diode standards

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In lamp industry it is usual to keep same type of lamp standards for the daily photometry of the specific test lamps. In LED measurement laboratories this is less of a practice, probably due to the fact that up to now the required measurement uncertainties were less demanding and because so many types of LEDs had to be handled that keeping a standard for every type seemed to be impractical.

Compared to traditional light sources LEDs differ mainly in their narrow emission band structure. Other characteristics, like different angular distribution and temperature sensitivity is less different from conventional so-called “special type” incandescent and discharge lamps.

A fluorescent lamp is also temperature sensitive, even more sensitive to drafts, and a sealed-beam lamp can have very narrow spatial light distribution. But while every photometrist knows that these lamps have to be to measured at constant temperature in still air and/or have to be measured in special fixtures, in case of LEDs they would like to use cheap measuring facilities. These facts put special pressure on the quality of standards to be used.

Modern LEDs are manufactured using compounds containing differing amounts of Ga, In, Al and N, P, As. The composition of these so called III-V compounds influences not only the band-gap of the semiconducting material, and thus their emission band shape and maximum, but also their current-voltage-light intensity characteristics, and the temperature dependence of these parameters. Depending on composition a temperature change of 10 °C can produce an intensity change of more then 10 per cent and chromaticity differences in the order of 10 ΔE^*_{ab}. Examples showing this effect for LEDs of different composition will be presented. For comparison standards the usual 1 to 2 °C temperature stability of an average laboratory is insufficient, thus LED standards have to have an internal temperature control of the semiconductor chip.

LEDs are often encapsulated in low temperature conducting plastic housings and it is difficult to measure the p-n junction temperature. Possibility to reach information on the junction temperature is given, however, by the very nature of the semiconducting junction. The current-voltage characteristics of a p-n junction is expressed by the equation

$$I = I_0 \{\exp(\mathrm{e}V/n\mathrm{k}T)-1\}$$

where I_0 is the saturation current, e the value of the elementary charge, V the p-n junction voltage, n a constant between 1 and 2, depending on the type of recombination taking place, k the Boltzmann constant, and T the temperature of the junction. Thus at constant current if the voltage is kept constant the temperature will be constant too.

This principle has been used in developing LED standards. We will show short and medium-long term stability data of LEDs built using this technique.

Also a new class of temperature stabilized LEDs will be introduced. These have been built using the so-called “Barracuda” type LEDs. These have a flat bottom and thus make the aligning of the LED in the direction of measurement relatively easy. On the other hand these LEDs have to be heat-sinked to avoid overheating. This has been achieved by using a copper heat-sink that could be used at the same time as agent for the temperature stabilization. Additional cooling below room-temperature can be added for certain cases where the same type of LEDs are expected to be used under special circumstances. This increased, however, the volume of the temperature stabilizer part of the LED.

In an other variant the LED and the emitting surface has been divided: a light pipe has been introduced. This enables the use of a more sophisticated temperature stabilizer and a flexible, easily mountable emitting part. This latter is in the form of a dummy 5 mm LED, and makes its use possible both in the CIE LED Intensity set-up and in an integrating sphere without any obstruction by the stabilizer part of the construction. External dimensions of the new LED standards are similar to the traditional versions.